Conclusions

-Development of system of automatic control of the process of champagne wines to install akratofor improves the quality of the finished product.

-To Improve performance in temperature control channel further measure temperature wine material and this information is used in a cascade ATS endpoint - the pressure of the wine material.

-Designed SCADA-system for process operators, allows you to monitor the progress of the process and manage the entire system from the operator's point.

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GRAPH MODELING OF THE GRAIN PROCESSING ENTERPRISE FOR SECONDARY EXPLOSION ESTIMATIONS

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Abstract

Mathematical model for the possible development of the primary explosion at the grain processing enterprise is created. It is proved that only instability is possible for the combustion process. This model enables to estimate possibility of the secondary explosion at any object of the enterprise and forms the base for mathematical support of the decision support system for explosion-proof. Such decision support system can be included in the control system of the processing enterprise.

Keywords

Grain processing enterprise, explosion, secondary explosion, decision support system, control system, graph, fuzzy estimation, the shortest path in the graph.

Introduction

There are a lot of explosions at the grain processing enterprises all over the world every year. Numerous researches and investigations are dedicated to the problem of the prevention of primary explosions, but there are too little scientific works concerning problems of secondary explosions. It is necessary to create effective control system for prevention of secondary explosions at the grain enterprises. Such control system must include appropriate decision support system (DSS).

Aim of the research is to create mathematical model for the possible development of the primary explosion at the grain enterprise. This model must give an opportunity to estimate possibility of the secondary explosion at any object of the enterprise in the presence of the primary explosion at the other object. DSS for explosion-proof of the grain processing enterprises must be based on such mathematical model.

Main body

Let us consider grain processing enterprise which consists of n different objects such as silos, bunkers, business buildings, conveyers etc. It is supposed, that fuzzy estimation $\tilde{E}_i$ ($0 \le \tilde{E}_i \le 1$) for the explosiveness of i-th object ($1 \le i \le n$) is known. Value $\tilde{E}_i$ can be estimated on the solution of the flame stability problem [1,2]. It is obvious that

$$\exists \alpha \in \{1, \ldots, n\} \ \tilde{E} = \tilde{E}_\alpha \quad \tilde{E}_\alpha = \max_i \tilde{E}_i , \tag{1}$$

where α is the number of the most explosive object of the enterprise, $\tilde{E}$ can be considered as the explosiveness of the enterprise as a whole and expresses the possibility of the primary explosion.

For every moment of the time grain processing enterprise is modeled by graph with n nodes. Every node corresponds to specific object of the grain processing enterprise. Two nodes i and j ($1 \le i \le n$, $1 \le j \le n$) are adjacent if the possibility $\tilde{S}_{ij}$ ($\tilde{S}_{ij} = \tilde{S}_{ji}$) of the penetrating of the fire or of the weak shock wave from the object i (to be more correct, from the object, corresponding to node i) into object j is more than zero; $\tilde{S}_{ij}$ is fuzzy value, that is $0 \le \tilde{S}_{ij} \le 1$.

This graph is undirected graph. It can be either connected or disconnected. If it is disconnected it means that it consists of two or more connected subgraph. Those subgraphs corresponds to such sites of the enterprise which are independent in terms of explosion-proof, that is the primary explosion at any object of any site can't be a reason for the secondary explosion at any object of the other site. So it is necessary to solve the problem of the graph connectivity and than to estimate separately the possibility of the secondary explosion for every site of enterprise corresponding to connected subgraph. So let us consider only connected graphs.

The graph is weighted. The weight of the node i is fuzzy estimation $\tilde{E}_i$. The weight of the edge ij is fuzzy value $\tilde{S}_{ij}$. The value of $\tilde{S}_{ij}$ depends on the physical way of connection for objects i and j. This graph is also fuzzy graph [3], because the weights of the nodes and the weights if the edges are fuzzy logical values [4].

To find the most explosive object in situation when object α (1) explodes (that is to find the most explosive object towards the possibility of secondary explosion) let us do such sequence of actions:

1. For every node i (except α) change the weight of the node from $\tilde{E}_i$ to $N\tilde{E}_i$, where

$$N\tilde{E}_i = \neg \tilde{E}_i = 1 - \tilde{E}_i \tag{2}$$

$N\tilde{E}_i$ is fuzzy estimation for inability of the object i to explode.

2. For every edge ij change the weight of the edge from $\tilde{S}_{ij}$ to $N\tilde{S}_{ij}$, where

$$N\tilde{S}_{ij} = \neg \tilde{S}_{ij} = 1 - \tilde{S}_{ij} \tag{3}$$

$N\tilde{S}_{ij}$ is fuzzy estimation for inability of penetrating of explosion from object i to object j.

3. In graph with new weights (modified graph) for every node i (except α) find the shortest path from node α to node i, changing previously every node (except α and i) to edge with weight $N\tilde{E}_i$. So every node i (except α) gets value $\tilde{P}_i^m$, where $\tilde{P}_i^m$ is the length of the shortest path in the graph. $\tilde{P}_i^m$ expresses inability of the object i to explode in the presence of the primary explosion at the object α. Problem of finding of the shortest path in the graph is solved by Dijkstra's algorithm [5].

4. It is obvious that

$$\exists \beta \in \{1, \ldots, n\} \ \beta \ne \alpha \quad \tilde{P}_\beta^m = \min_i \tilde{P}_i^m , \tag{4}$$

Object β is the object with the minimal inability for secondary explosion, that is object β is the most explosive object in the presence of the primary explosion at the object α.

5. There is the path in initial graph that corresponds to the shortest path from node α to node β. Let us change in this path every node (except α and β) to edge with weight $\tilde{E}_i$ (that is with initial weight of the node i) and then find the length of

this path. The length of the path divided by the number of edges in the path (let us mark such value as $S\tilde{E}_\beta$) can be taken as fuzzy estimation for possibility of secondary explosion of object β , which is the most explosive object in terms of secondary explosion.

Technological processes of grain storage and grain processing are modeled as the sequence of steps. Those steps are divided with important technological operations or organizational events (such as loading of grain into silos, aspiration, cleanup or wet cleaning). Every step in sequence of technological processes corresponds to the graph described above. Every transition from one step to another changes weights of nodes and weights of edges. That means that explosiveness of different objects of grain processing enterprise changes and ability for penetration of explosion from one object to another changes also.

Transition from one step of technological processes to another sometimes leads to changing of corresponding graph. New edges can be added to graph; some edges can be deleted. For example, filling of silo leads to removal of the edge, connecting two nodes; one of these nodes corresponds to this silo, the other node corresponds to the under-silo gallery. Closing of a silo makes the node, corresponding this silo, the isolated node of the graph. It is obvious, that addition or removal of the graph nodes as a result of any technological operation or organizational event is impossible; addition of the node means appearance of new object at the grain processing enterprise, removal of the node means vanishing of some object (corresponding to this node) at the grain processing enterprise, such appearances and disappearances are possible only as a result of the reconstruction or rebuilding of this enterprise. So nodes of the graph are invariable, but their weights are changeable.

Thereby for every step of technological processes reassessment of explosiveness of every object of the enterprise is done. Ability of every object for primary explosion and secondary explosion (in presence of the primary explosion of the most explosive object) is reassesed and scenarios of the explosion development are reviewed. Control action must be applied:

1) to the most explosive object in terms of the primary explosion;

2) to the most explosive object in terms of the secondary explosion in presence of the primary explosion of the most explosive object item 1).

Control action aims to decrease explosiveness of the objects. This action can be technical, technological or organizational. The example of technical control action is phlegmatization or inhibition; the example of technological control action is technological operation such as silo filling; the examples of organizational control action are cleanup and wet cleaning. Selection of the appropriate control action is prerogative of decision maker, but DSS on the base of the described above mathematical model prompts the decision maker direction of the action, that is DSS recommeds the decision maker the objects for immediate control action.

Conclusions

Solving of the described above problem enables to enlarge and to improve DSS for explosion-proof of the grain processing enterprises of different types: elevators, flour milling plants, compound feed plants. This DSS enables:

- to specify the most explosive objects of the grain processing enterprise either in terms of the primary explosion or in terms of the secondary explosion in presence of the primary explosion;
- to specify the most effective control actions (be technical, technological or organizational) for ensuring of the explosion safety of the grain processing enterprise;
- to specify the most effective control actions for suppression of the secondary explosions, such actions prevent development of explosions.

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